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(54) **Oil/sludge separation**

(57) Apparatus for separating oil and sludge comprises a cylindrical tank 1 leading (5) into an elongate chamber 6 which contains a plurality of cones 7, 7' arranged at the top of the chamber 6. Reservoir pipes 8 lead out of the chamber 6 from the base of each pair of cones 7, 7'. Oil/sludge is pumped into the tank 1 where it spins in a vortex V_1, separating the oil from the sludge. The sludge is removed from the bottom of the tank 1 and the oil rises from the centre of the vortex through a body of water, also spinning in a vortex V_2, in the lower portion of the chamber 6 until it reaches the cones 7, 7'. The oil passes in a tortuous path between the cones and out of the top of the chamber 6 via outlet pipe 11. As the oil passes between the cones 7, 7' any water present in the oil passes down the pipes 8; oil is prevented from passing down through the pipes 8 by the presence of water in the pipes 8. The apparatus may alternatively be used for fractional distillation of oil.

Figure 1

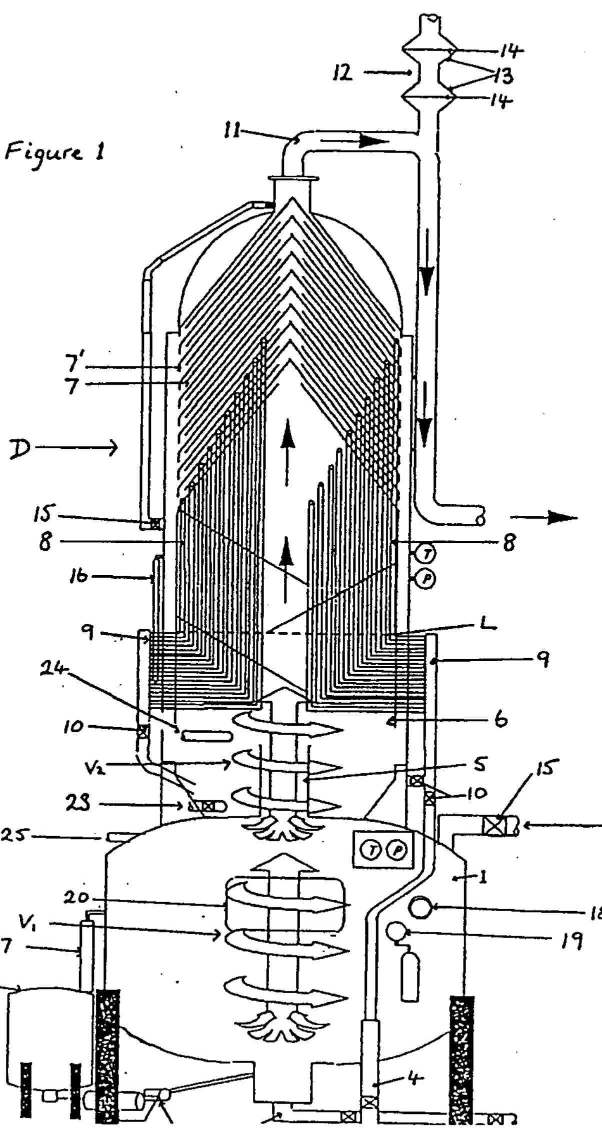

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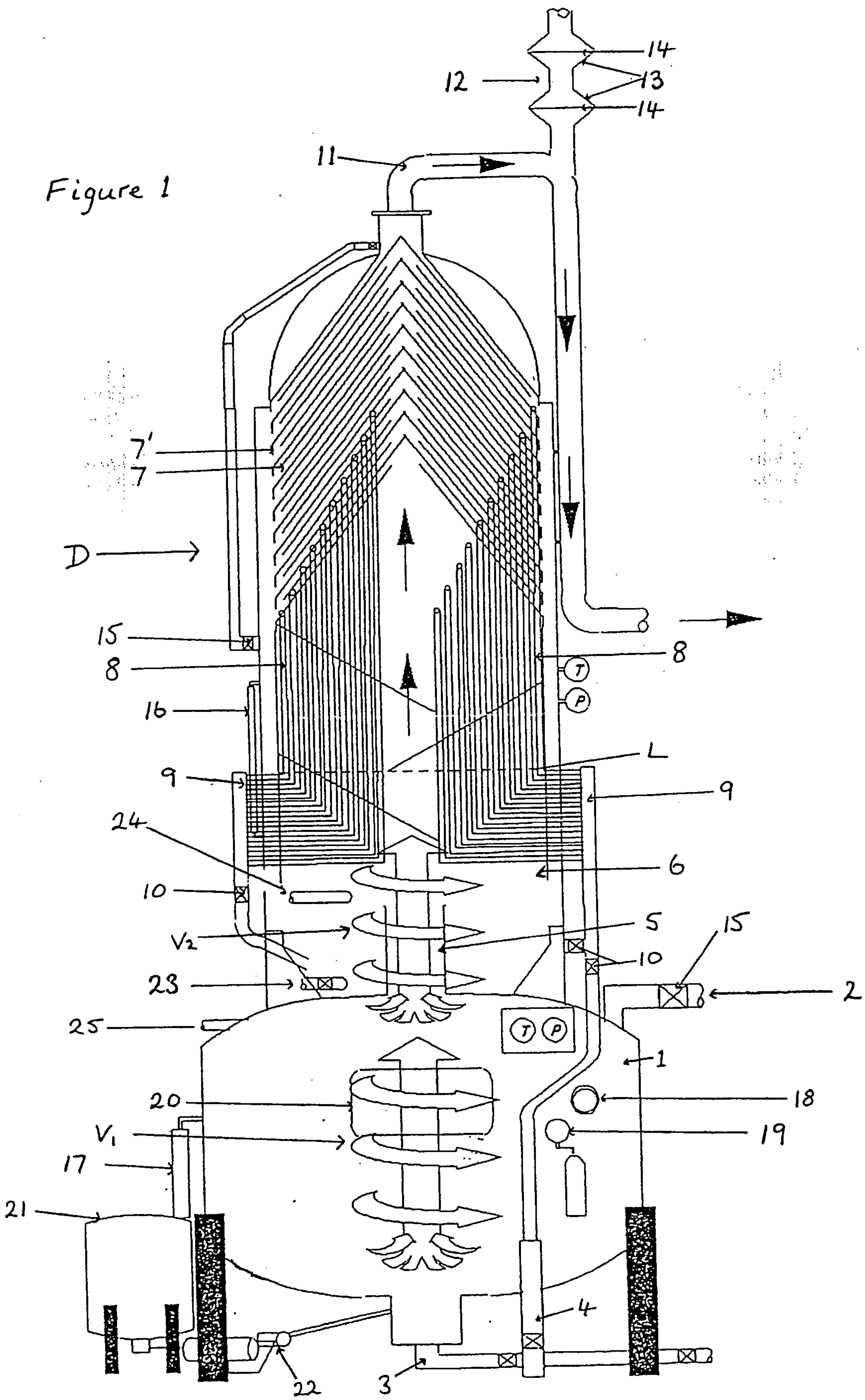
Figure 1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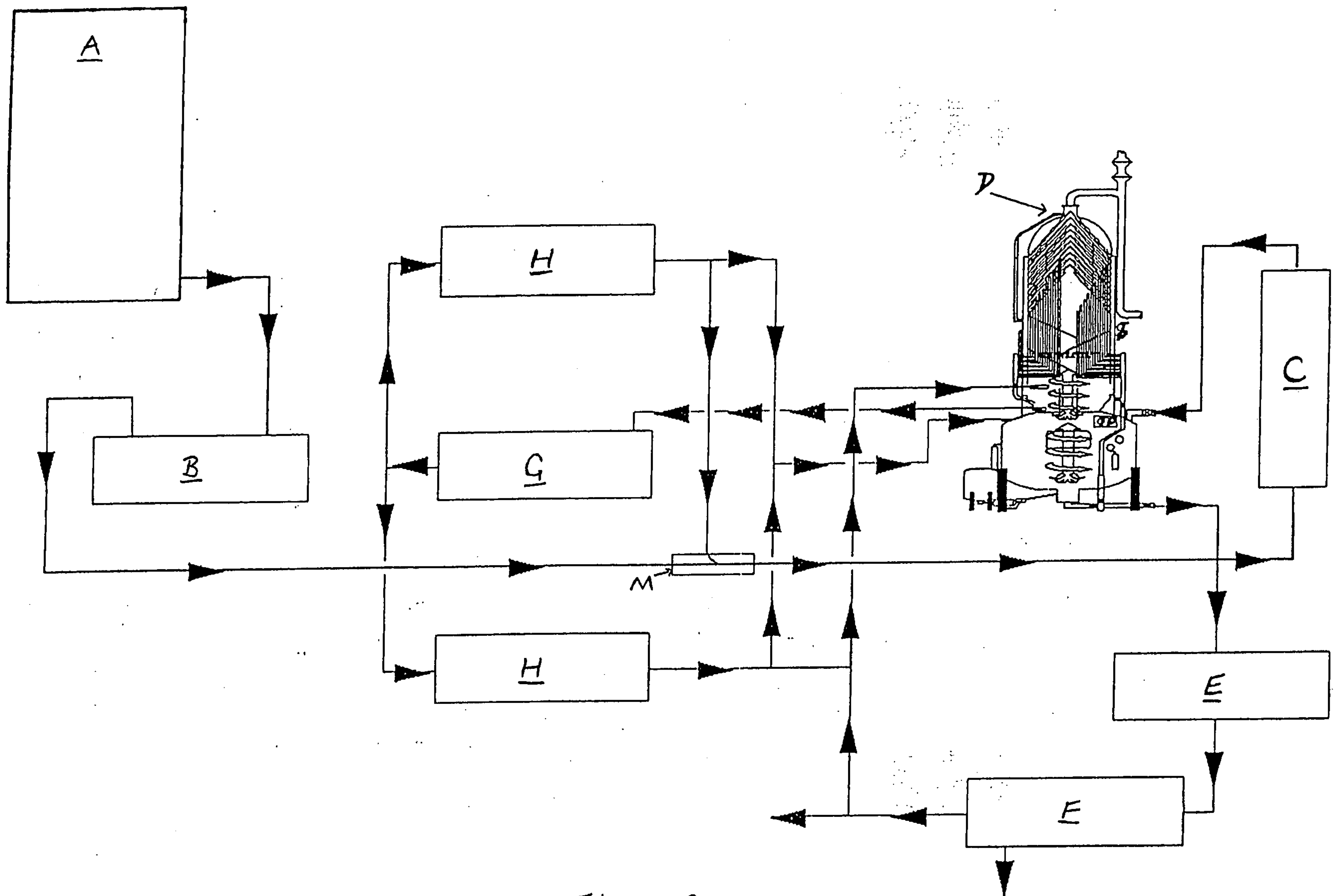

Figure 2

OIL/SLUDGE SEPARATION

This invention relates to a process for separating oil and sludge and to apparatus for carrying out the process.

Crude oil is a mixture of oil with sludge and water and it is therefore necessary to separate the oil from the sludge and water before it can be used. The most common methods of separation currently used are based on a centrifugal technique. The equipment used is very large, requires a lot of maintenance and the process is very expensive.

The present invention seeks to provide an improved method of oil/sludge separation using apparatus which is cheaper and more convenient and provides a faster and more efficient separation process.

The present invention provides apparatus for separating oil and sludge comprising a cylindrical tank,one end of the tank possessing an opening which leads into an elongate chamber, a plurality of hollow cones situated towards the end of the chamber remote from the tank, each cone being situated within but spaced from its neighbour, the apex of each cone being towards the end of the chamber remote from the tank, the cone nearest the tank and every alternate cone therefrom being open at the apex, the base edge of each open cone extending to the walls of the chamber and the base edge of the remaining cones

being spaced from the walls of the chamber, a reservoir extending from the base of the space between each adjacent pair of plates at the exterior of the elongate chamber and an oil outlet pipe extending from the end of the chamber remote from the tank.

The elongate chamber is usually cylindrical and therefore has a circular cross-section. However, where the elongate chamber is not cylindrical, the cones are adapted to have the same cross-sectional shape as the chamber. The number of cones used can be varied greatly and the spacing between the plates may be varied according to the number of cones used. The opening in the cylindrical tank comprises a duct which leads from one end of the cylindrical tank into the elongate chamber.

Preferably, the cylindrical tank is provided with at least one outlet pipe for removal of sludge from the tank. The outlet pipe is provided with a valve so that the sludge can be removed from the tank either continuously or at intervals. The sludge outlet pipe may be connected to other apparatus such as a filter as will be described later.

The cylindrical tank is preferably provided with an oil/sludge inlet pipe which is adapted to be connected to a heat exchanger. The oil/sludge mixture can therefore be pumped into the cylindrical tank at the desired temperature, according to the particular components of the mixture.

Desirably, the elongate chamber is provided with a water outlet pipe at the end of the chamber adjacent the cylindrical tank, and the cylindrical tank and the elongate chamber are each provided with a water inlet pipe, the water inlet pipes being adapted to be connected to a pump. The water outlet and inlet pipes enable water to be removed, heated and pumped back in to either or both the elongate chamber and the cylindrical tank to help maintain the temperature and momentum of the water and oil in the apparatus.

Desirably, each reservoir comprises a pipe which extends from between the base of each adjacent pair of plates to and along the exterior of the chamber. The pipes join at least one collecting pipe which extends from the exterior of the chamber into the portion of the chamber adjacent the cylindrical tank. The or each collecting pipe is provided with a valve. Thus, liquid in the collecting pipe can either be removed from the pipe or can re-enter the chamber.

The oil outlet pipe is provided with a vent pipe which allows the escape of any gases from the outlet pipe. The vent pipe comprises at least one portion of increased diameter, said portion containing a perforated disc substantially perpendicular to the pipe. Any gases present in the oil outlet pipe can rise and pass out through the vent pipe. However, any oil which attempts to rise up the vent pipe will be prevented from leaving by the perforated disc which is only permeable to gases.

The present invention also provides a process for separating oil and sludge using apparatus in accordance with the invention comprising pumping the oil/sludge mixture into the cylindrical tank under pressure so that the force of the impact of the mixture against a wall of the tank causes the mixture to spin in a vortex, providing a body of water in the lower portion of the elongate chamber which is adjacent the cylindrical tank such that oil passing to the centre of the vortex will rise from the centre of the vortex through the body of water and continue to rise until it reaches the plurality of cones allowing the oil to pass between the plates and removing the oil from the end of the elongate chamber remote from the cylindrical tank. Both the oil/sludge mixture and the oil and sludge that leave the cylindrical tank will contain water and the terms oil and sludge are used in the claims to allow for the presence of water. The action of the vortex in the cylindrical tank is such as to separate the sludge and other dirt particles from the oil. Due

to the density differences, the sludge and dirt remain at the outside of the vortex and the oil moves to the centre of the vortex, much of the water going to the interface between the sludge and the oil. The oil will rise from the centre of the vortex up through the body of water due to the relative densities of oil and water and will gradually rise up to the top of the chamber from where it is then removed.

The sludge which remains at the outside of the vortex in the cylindrical tank is removed from the cylindrical tank.

Water present in the oil will, as the oil passes upwards between the cones, pass down a reservoir extending from the base of the space between each adjacent pair of cones.

Each reservoir is filled with water to the same level as the water in the elongate chamber to prevent oil from passing down the reservoir below this level.

Water is removed from the lower portion of the elongate chamber adjacent the cylindrical tank, passed through a heat exchanger and then pumped back to either or both the lower portion of the elongate chamber and the cylindrical tank. The water which is pumped back into the lower portion of the elongate chamber causes the body of water present in said lower portion

to spin in a vortex. This helps to ensure that the oil rising from the cylindrical tank passes substantially straight upwards to the cones and does not spread out before reaching the cones.

A preferred embodiment of the invention will now be described in details with reference to the accompanying drawings, in which:-

Figure 1 is a part-schematic section through the separation apparatus;

Figure 2 is a diagrammatic view of a complete system using the separation apparatus of the invention.

Referring first to Figure 1, the separation apparatus, generally designated D, comprises a cylindrical tank 1 which is provided with an oil/sludge inlet pipe 2 and two sludge outlet pipes 3,4. A duct 5 leads from the tank 1 into an elongate cylindrical chamber 6. A plurality of cones 7,7′ are situated in the top portion of the chamber 6. Typically, 20 cones are used but this number can be varied greatly. The cones 7,7′ are arranged so that they are stacked on the top of each other but are spaced from each other and the apex of each cone 7,7′ is towards the end of the chamber 6 remote from the tank 1 which in

use is the top of the chamber 6. The cone 7′ nearest the tank 1 and every alternate cone 7′ therefrom, is open at its apex to allow for passage of oil.

The base edge of each open cone 7′ extends to the wall of the chamber 6 but the base edge of each alternate closed cone 7 is spaced from the wall of the chamber 6 to allow for the passage of oil.

Two reservoir pipes 8 extend from between the base of each adjacent pair of cones 7,7′ to the exterior of the chamber 6 and extends down the exterior of the chamber 6 until they join respective collecting pipes 9. The pipes 8 are shown schematically on Figure 1 but each pipe 8 leaves its respective pair of cones 7,7′ at a different point around the diameter of the chamber 6. The collecting pipes 9 extend from the pipes 8 on the exterior of the chamber 6 back into the lower portion of the chamber 6 but is provided with a valve 10 so that liquid can either be removed from the apparatus or can re-enter the chamber 6. One of the collecting pipes 9 also extends beyond the cylindrical tank 1 to join the outlet pipe 4.

An oil outlet pipe 11 extends from the top of the chamber 6 and this outlet pipe 11 is provided with a vent pipe 12. The vent pipe 12 comprises 2 portions 13 of increased diameter and a perforated disc 14 extends across the pipe 12 at each of these portions 13.

Non-return valves 15 are provided both on the wall of the chamber 6 and on the inlet pipe 2. Temperature and pressure gauges are provided both on the chamber 6 and on the tank 1 and are indicated on the Figure by T and P respectively. A level indicator 16 is provided on the exterior of the chamber 6 and a further level indicator 17 is provided on the exterior of the tank 1. A sight glass 18, a sampler 19 and an access door 20 are also provided on the tank 1. A chemical treatment tank 21 and injector 22 are situated adjacent the tank 1 for use if necessary.

A water outlet pipe 23 and a water inlet pipe 24 are provided at the base of the elongate chamber 6 and a further water inlet pipe 25 is provided. In an alternative embodiment of the invention, the water outlet pipe 23 and water inlet pipe 24, 25 can be omitted.

The cylindrical tank 1 and chamber 6 are typically made from stainless steel. The cones 7,7′ may be made from mild steel or stainless steel.

Figure 2 is a diagram of a complete system of apparatus that can be used with the apparatus of Figure 1 to provide a complete oil/sludge separation unit. A storage tank A is connected to a pump B which in turn is connected to an Auger mixer M. The mixer M is in turn connected to a large heat exchanger C which is connected to the separation apparatus D of Figure 1. The sludge outlet pipes 3,4 of the separation apparatus D are connected via a pump E to a decanter F. Sludge from the decanter can drain from the bottom of the decanter F into a skip. Water from the decanter F may be removed to waste W or may be fed back into the separation unit D.

The water outlet pipe 23 from the separation unit D is connected to a small heat exchanger G, which is in turn connected to two pumps H, H^1. The pumps H, H^1 are connected to the water inlet pipes 24, 25 of the separation unit D. In an alternative embodiment of the invention, where the water outlet pipe 23 and water inlet pipes 24, 25 are omitted, the small heat exchange G and pumps H, H^1 can also be omitted.

In the oil/sludge separation process of the present invention, the separation apparatus D is first prepared by filling the chamber 6 and the collecting pipe 9 and reservoir pipes 8 with water to level L shown by the dotted line in Figures 1 and 2. This water level is monitored throughout the process by the level indicator 16 and is kept constant. The

oil/sludge mixture is pumped from the storage tank A via the Auger mixer M, where water is added if required, and the heat exchanger C into the cylindrical tank 1 via the oil/sludge inlet pipe 2. The temperature of the mixture on entry into the tank 1 is typically 80°C to 90°C but this can be varied according to the particular product to be obtained. The oil/sludge enters the tank 1 at approximately 150 psi (1034 kN/M^2) and the force of impact of the oil/sludge against the inside wall of the tank 1 causes the oil/sludge to start spinning by a venturi-type action. The vortex formed is illustrated diagrammatically in Figure 1 and is designated V_1. The relative densities of oil and sludge automatically separate the oil from the sludge as it spins in the vortex V_1. The sludge remains at the outside of the vortex V_1 and collects around the walls of the tank 1. The sludge is removed from the bottom of the tank 1 via the outlet pipes 3,4 and can then be pumped by the pump E to the decanter F where the waste water is removed from the sludge. The oil moves to the centre of the vortex V_1 and most of the water collects at the interface between the sludge and the oil. As oil moves to the centre of the vortex V_1, it must pass through this water interface and this serves to wash the oil.

Oil from the centre of the vortex rises upwards and passes through the duct 5 into the chamber 6. It continues to rise up through the water due to the density difference and as it passes through the water in the chamber it is further washed. Water is

removed from the bottom of the elongate chamber 6 by the water outlet pipe 23 and passed through the small heat exchanger G. It is then pumped by the pumps H, H^1 back into both the elongate chamber 6 and the cylindrical tank 1 by the water inlet pipes 24, 25.. This heated and pressurised water helps to maintain the desired temperature of the water and oil in the apparatus and also to maintain the momentum of the vortex V_1 in the cylindrical tank. Furthermore, the entry of water at high pressure into the bottom of the elongate chamber 6 establishes a second vortex V_2 in the body of water there. This second vortex ensures that the oil passes straight upwards through the body of water and does not spread out. The water which is removed from the elongate chamber by water outlet pipe 23 is being taken from a "calm area" of the vortex V_2 to ensure that no oil is inadvertently removed with the water.

From the water, the oil gradually rises up the chamber 6 until it reaches the lowest cone 7′. When it reaches the open apex of the cone 7′, it passes through and down between the cone 7 and its adjacent neighbour cone 7. When it reaches the base of the cone 7, the oil will enter the first pipe 8. However, it will only pass down the pipe 8 as far as the water at the level L. It will not pass down through the water because of its density difference with water. When the first pipe 8 is full of oil, the oil must pass up between the cone 7 and its adjacent neighbour cone 7′ above until it reaches the next open apex,

where it will pass through and down to the next pipe 8. When this second pipe 8 is full of oil, the oil must continue upwards between the cones 7′,7 and this process continues until the oil reaches the top of the chamber 6. The oil thus follows a tortuous path between the cones in order to reach the top of the chamber 6 and the passage of oil between the cones is indicated by arrows in Figure 1.

As the oil passes between the cones 7,7′, any water present in the oil will, due to the relative densities, pass down the pipes 8 through the oil and into the collecting pipe 9. From here, the water may either re-enter the chamber 6 or may be removed via the valve 10.

By the time the oil reaches the top of the chamber, it should be substantially pure and is removed from the chamber via the oil outlet pipe 11. Any gas present in the oil will escape through the vent pipe 12, passing through the perforated discs 14. However, oil is prevented from going through the vent pipe 12 by the discs 14 and the increase in gas pressure caused by gas leaving the increased diameter portion 13 which tends to push the liquid back down.

At the end of the process, the separation apparatus D may be drained and air will enter the apparatus through the non-return valve 15 to prevent an implosion of the apparatus.

The separation apparatus D may also be used as distillation apparatus to separate different oil fractions. In this case the vent pipe 12 is closed, the non-return valve 15 is replaced by an ordinary closed valve and the apparatus is placed under vacuum. The pipes 8 will act as reflex apparatus. The apparatus is set at the temperature of the first oil fraction and as the first oil fraction boils off, the vapour passes up through the cones 7,7′ and out into the oil outlet pipe 11 where is condenses. The apparatus is then heated to the temperature of the next oil fraction and so on.

The present invention provides a fast, efficient method for separating oil from sludge which is much cheaper than prior art processes. The separating apparatus is easy to maintain as it contains no moving parts, the separation being achieved by natural forces such as gravity. Furthermore, the process has the advantage that the oil is washed during the separation process.

CLAIMS

1. Apparatus for separating oil and sludge comprising a cylindrical tank, one end of the tank possessing an opening which leads into an elongate chamber, a plurality of hollow cones situated towards the end of the chamber remote from the tank, each cone being situated within but spaced from its neighbour, the apex of each cone being towards the end of the chamber remote from the tank, the cone nearest the tank and every alternate cone therefrom being open at the apex, the base edge of each open cone extending to the walls of the chamber and the base edge of the remaining cones being spaced from the walls of the chamber, a reservoir extending from the base of the space between each adjacent pair of cones at the exterior of the elongate chamber and an oil outlet pipe extending from the end of the chamber remote from the tank.

2. Apparatus according to Claim 1, wherein the cylindrical tank is provided with at least one outlet pipe for removal of sludge from the tank.

3. Apparatus according to Claim 1 or 2, wherein each reservoir comprises a pipe which extends from between the base of each adjacent pair of cones to and along the exterior of the chamber.

4. Apparatus according to Claim 3, wherein the pipes join at least one collecting pipe which extends from the exterior of the chamber into the portion of the chamber adjacent the cylindrical tank.

5. Apparatus according to Claim 4, wherein the or each collecting pipe is provided with a valve.

6. Apparatus according to any preceding claim, wherein the oil outlet pipe is provided with a vent pipe which allows the escape of any gases from the outlet pipe.

7. Apparatus according to Claim 6, wherein the vent pipe comprises at least one portion of increased diameter, said portion containing a perforated disc substantially perpendicular to the pipe.

8. Apparatus according to any preceding claim, wherein the cylindrical tank is provided with an oil/sludge inlet pipe which is adapted to be connected to a heat exchanger.

9. Apparatus according to any one of the preceding claims wherein the elongate chamber is provided with a water outlet pipe at the end of the chamber adjacent the cylindrical tank, the water outlet pipe being adapted to be attached to a heat exchanger.

10. Apparatus according to any one of the preceding claims wherein the end of the elongate chamber adjacent the cylindrical tank and the cylindrical tank are each provided with a water inlet pipe, the water inlet pipes being adapted to be connected to a pump.

11. Apparatus according to any preceding claim, wherein the opening in the cylindrical tank comprises a duct which leads from one end of the cylindrical tank into the elongate chamber.

12. A process for separating oil and sludge using apparatus according to any preceding claim comprising pumping the oil/sludge mixture into the cylindrical tank under pressure so that the force of the impact of the mixture against a wall of the tank causes the mixture to spin in a vortex, providing a body of water in the lower portion of the elongate chamber which is adjacent the cylindrical tank such that oil passing to the centre of the vortex will rise from the centre of the vortex through the body of water and continue to rise until it reaches the plurality of cones allowing the oil to pass between the cones and removing the oil from the end of the elongate chamber remote from the cylindrical tank.

13. A process according to Claim 12, wherein the sludge remains at the outside of the vortex in the cylindrical tank and is removed from the cylindrical tank.

14. A process according to Claims 12 or 13, wherein water present in the oil will pass down a reservoir extending from the base of the space between each adjacent pair of cones as the oil passes between the cones.

15. A process according to Claim 14, wherein each reservoir is filed with water to the same level as the water in the elongate chamber to prevent oil from passing down the reservoir below that level.

16. A process according to any one of Claims 12 to 15 wherein water is removed from the lower portion of the elongate chamber adjacent the cylindrical tank, passed through a heat exchanger and then pumped back to either or both the lower portion of the elongate chamber and the cylindrical tank.

17. A process according to Claim 16 wherein the water which is pumped back into the lower portion of the elongate chamber causes the body of water present in said lower portion to spin in a vortex.